Photophoretic transport of fractal-like soot aggregates in stratosphere

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Ecological and atmospheric applications of processes of radiation absorption and motion of soot particles are well-known under the numerous publications reflecting various aspects of this problem. The theoretical description of photophoretic motion of soot aggregates, as a rule, is carried out for the model of homogeneous spherical particles without the necessary account of fractal-like structure of aggregates that can result not only in quantitative distinctions, but also to qualitative errors at the description of effects.

Nowadays, the theory of longitudinal radiometric photophoresis for spherical homogeneous particles by Beresnev *et al* (1993) has found confirmation in experiments with model macroscopic particles and real aerosols for a complete set of determining parameters. However, the most part of soot (black carbon) atmospheric particles have a fractal-like structure, and we can expect essential changes of thermal and optical characteristics of these particles in comparison with homogeneous spheres.

This report continues and summarizes analysis and estimations of the photophoretic effects for soot aerosols in stratosphere on the basis of new microphysical model offered by Beresnev *et al* (2014, 2015). The principal propositions of the new model are the following:

1. It is useful to keep the mathematical formalism used in model for spherical homogeneous spheres by Beresnev *et al* (1993) at correct treatment of key parametres (the detailed general solution for fractal-like particles is extremely difficult and problematic). Besides, the fractal-like soot aggregates in experiment (Karasev *et al*, 1984) demonstrate confidently the ordinary longitudinal positive photophoresis in the field of directed laser radiation, and their photophoretic motion is very similar to the motion of compact (isometric) carbonaceous particles.

2. For rigorous theoretical predictions of the photophoretic velocity of fractal-like aggregates it is possible to use in a first approximation the mobility radius R_m only. For more exact theoretical predictions the introduction of a set of equivalent spheres characterizing various aspects of the given phenomenon is necessary.

3. The correct estimation of effective density ρ_{eff} and effective heat conductivity λ_{eff} of fractal-like aggregates as certain equivalent spheres with radius of gyration R_g (and the corresponding mobility radius R_m) can be successfully executed on the basis of fractal dimension of aggregates D_f and characteristics of primary particles (Evans *et al*, 2008). Estimations under the reference data for soot powders can be erroneous in this case.

The new microphysical model allows to carry out the estimations of photophoretic effects for soot aerosol in atmosphere similar with executed earlier by Beresnev *et al* (2012) for model of homogeneous spherical particles. The analysis of received results shows that for fractal-like soot particles the essential photophoretic effects in stratosphere are important: the considerable photophoretic vertical velocities, excess of photophoretic forces over gravity, possibility of a levitation of particles at certain altitudes in the middle stratosphere, and many other things.

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